January 2016

Test Record for the Explosive Atmosphere (EA) Test of the TDFM-9000 Radio to Be Installed in the CH-47F Chinook Helicopter

ATEC Project No: 2014-DT-RTC-ICHXX-F7803

RTC Document No: RTC-16-F7803-0305

Division Document No: LR-RT-MSP-EX86-16-031

Mr. Samuel C. Davis

Produced by
The US Army Redstone Test Center

Produced for
Project Management - Cargo (PM Cargo)

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14 December 2015

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Propulsion Test Division Test Engineer

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SECURITY STATEMENT

Operations Security (OPSEC) was considered in the development of this test report. The RTC Memo 380-7, "Operations Security Plan for Redstone Test Center," dated 18 June 2012, was adhered to during this test.

The "CH-47 Security Classification Guide," dated 8 September 2010 was followed for classification of test results as required.

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13.SUPPLEMENTARY NOTES

14.ABSTRACT

This test report documents the key findings from the Explosive Atmosphere (EA) test of the TDFM-9000 Radio conducted at the Redstone Test Center (RTC) on 14 December 2015.

15.SUBJECT TERMS

EA (Explosive Atmosphere), TDFM, radio

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

SECTION 1.0 EXECUTIVE DIGEST

This test report documents the key findings from the Explosive Atmosphere (EA) test of the TDFM-9000 Radio conducted at the Redstone Test Center (RTC) on 14 December 2015. It should not be construed as the Army Test and Evaluation Command (ATEC) system evaluation report or system assessment for the TDFM-9000 Radio.

1.1 SUMMARY

The TDFM-9000 transceiver (Figure 1) is an airborne multi-band radio capable of operation in conventional, analog and P25 digital Frequency Modulated (FM) systems, SmartNet/SmartZone trunking systems and P25 9600 trunking systems. Radio Frequency (RF) modules are available in single or dual bands that support Very High Frequency (VHF), Ultra-High Frequency-Low (UHF-Lo), UHF-High (UHF-Hi), and 700-800 MegaHertz (MHz) bands. Up to six single or dual band modules can be supported. Each radio module can store 2,000 channels and can be programmed to operate in digital or analog mode on a channel-by-channel basis. Built-in audio switching allows multiple RF modules in either combined or separate transceiver configurations.

Figure 1. TDFM-9000 Radio, Typical.

This report describes the specific subtests performed by the RTC Propulsion Test Division for the EA testing of the TDFM-9000 Radio as installed on the CH-47F helicopter.

A vacuum chamber was used to simulate a range of pre-determined altitudes, based on data for a standard atmosphere. Subtests consisted of evaluating the test item in an explosive atmosphere, a fuel-air mixture simulated by n-hexane and air, at altitudes ranging from approximately 23,300 feet (ft) to 16,700 ft above sea level and from 3,300 ft to site level. The test criterion was to determine whether operation of the test item during the aforementioned altitude ranges would cause ignition of the explosive atmosphere.

The EA testing regimen was conducted in support of the Project Management - Cargo (PM Cargo).

1.2 CONCLUSIONS AND RECOMMENDATIONS

The TDFM-9000 Radio was tested successfully, without igniting the fuel in the vacuum chamber. There were no test or data anomalies.

SECTION 2.0 SUBTESTS

2.1 EA TEST

The test equipment used by the RTC Propulsion Test Division is listed in Table 1. Pressure within the vacuum chamber was measured and monitored by a pressure gauge, and any test items requiring temperature readings were instrumented with copper-constantan thermocouples (TC). The RTC Propulsion Test Division installed the TCs prior to the test and monitored the TCs throughout the testing regimen.

Table 1. Test Equipment Used in EA Testing

RTC – Propulsion Test Division Test Equipment				
Equipment Name	**Manufacturer**	**Model**	**Serial Number**	**Calibration Date**
Computer	Dell	Precision R5500	N/A	N/A
Software	FALCN Programmer: Nate Keller	N/A	N/A	N/A
Pressure Gauge	Sensotec	PPA	1436754	25 September 2015 (next calibration date: 25 September 2016)
Type of Thermocouples Used	Omega Engineering Inc.	Self adhesive thermocouple SA1-T	N/A	N/A
Test Chamber	Tenney Engineering Inc.	Explosion 4D 6	9961	N/A

2.1.1 Objectives

The objective of the EA testing is to determine the ability of the test item to operate in an explosive atmosphere without causing ignition. The test item will be evaluated for its sustained operability in an explosive atmosphere at various partial pressures related to its altitude equivalents, without experiencing undue hazards.

2.1.2 Criteria and Analysis

2.1.2.1 Criteria

The following references were consulted for the test:

1. *Test Plan for the Safety of Flight (SOF) Explosive Atmosphere (EA) Test of the TDFM-9000 Radio to Be Installed on the CH-47F Chinook Helicopter,* September 2015.

2. MIL-STD-810G, *Environmental Engineering Considerations and Laboratory Tests*, Method 511.5, Procedure I, 31 October 2008.

3. *Explosive Atmosphere Vacuum Chamber Operations*, TEDT-RT-SOP-385-M4054, 3 February 2014.

In accordance with (IAW) the test plan, the failure criterion is defined as ignition of the explosive atmosphere resulting from the operation of the test item.

2.1.2.2 Analysis

Data graphs showing the rate of altitude versus time, as well as the temperature versus time, are provided in Appendix B.

2.1.3 Test Procedures and Findings

2.1.3.1 Test Procedures

Prior to testing, the test item was visually inspected by personnel from the RTC Propulsion Test Division to establish the baseline condition (e.g., item integrity, operability) in the un-powered state. Anomalies or discrepancies, if any, such as loose fasteners or connections, loss of integrity of seals or sealants, or permanent distortion or deformation of material possibly affecting item functionality, were recorded. A baseline Functional Checkout Procedure (FCP) was performed at ambient temperature to ensure that the test item was functioning properly. A copy of the FCP log is included in Appendix C.

The test item was placed on a test bed inside the vacuum chamber in such a manner that it could be operated and controlled from the exterior of the chamber via sealed cable ports (Figure 2). All other hardware required to operate the test item was located outside the chamber.

Figure 2. Item Under Test Inside the Vacuum Chamber.

Instrumentation appropriate to the test was installed on the test item and checked for operability, reliability, and calibration, if applicable. In addition to chamber wall temperature and air temperature readings, one TC was placed on the test item as shown in Figure 3.

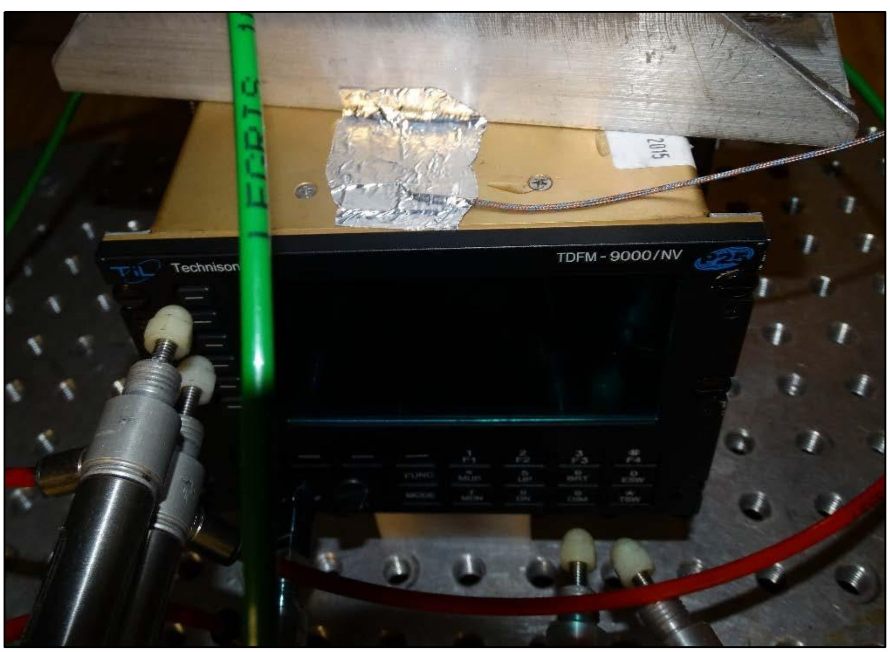


Figure 3. TC-1 on the TDFM-9000 Radio.

In addition to the TC, five pneumatic actuators were utilized to operate the TDFM-9000 Radio, as follows:

1. Actuator A turned and depressed the power and volume knob (Figure 4).
2. Actuators B and C depressed the channel selector buttons (Figure 5).
3. Actuators D and E depressed the “DIM” and “BRT” buttons, respectively (Figure 6).

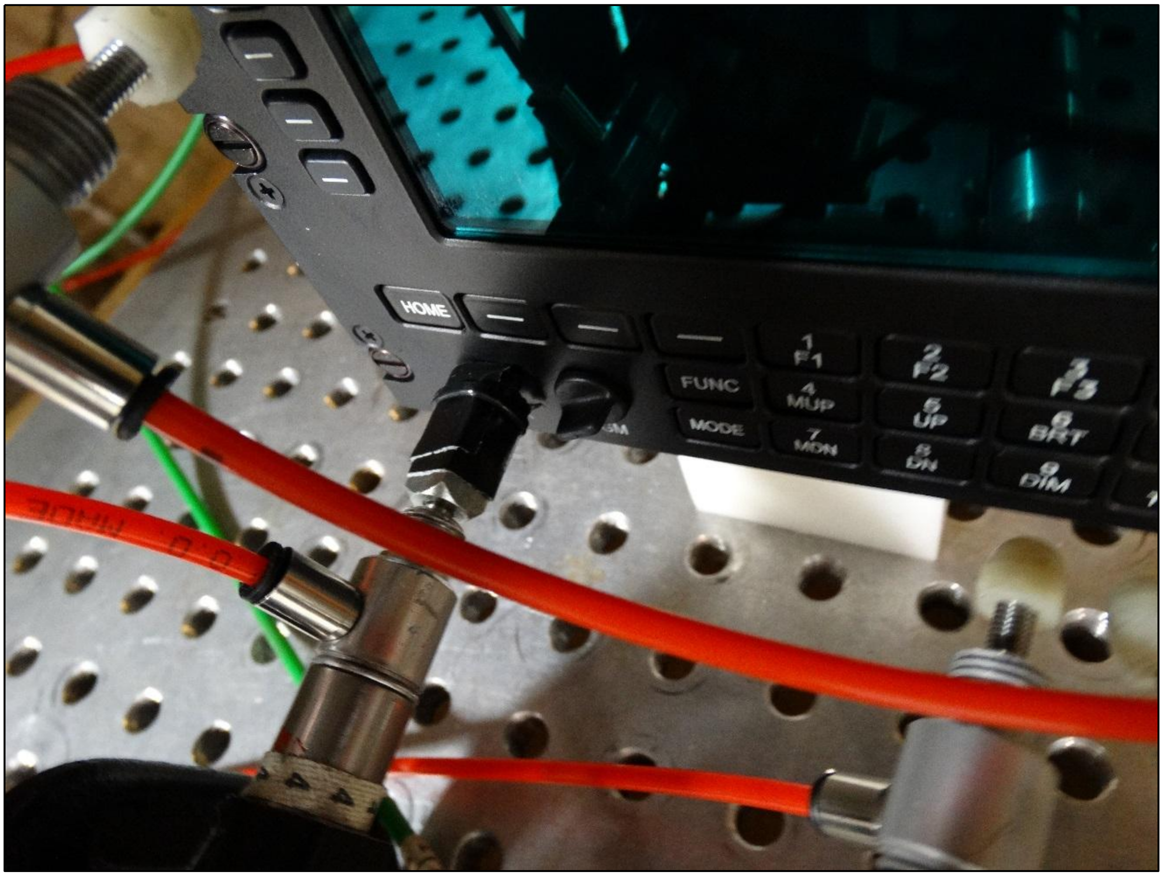


Figure 4. Actuator A Operating the Power and Volume Knob.

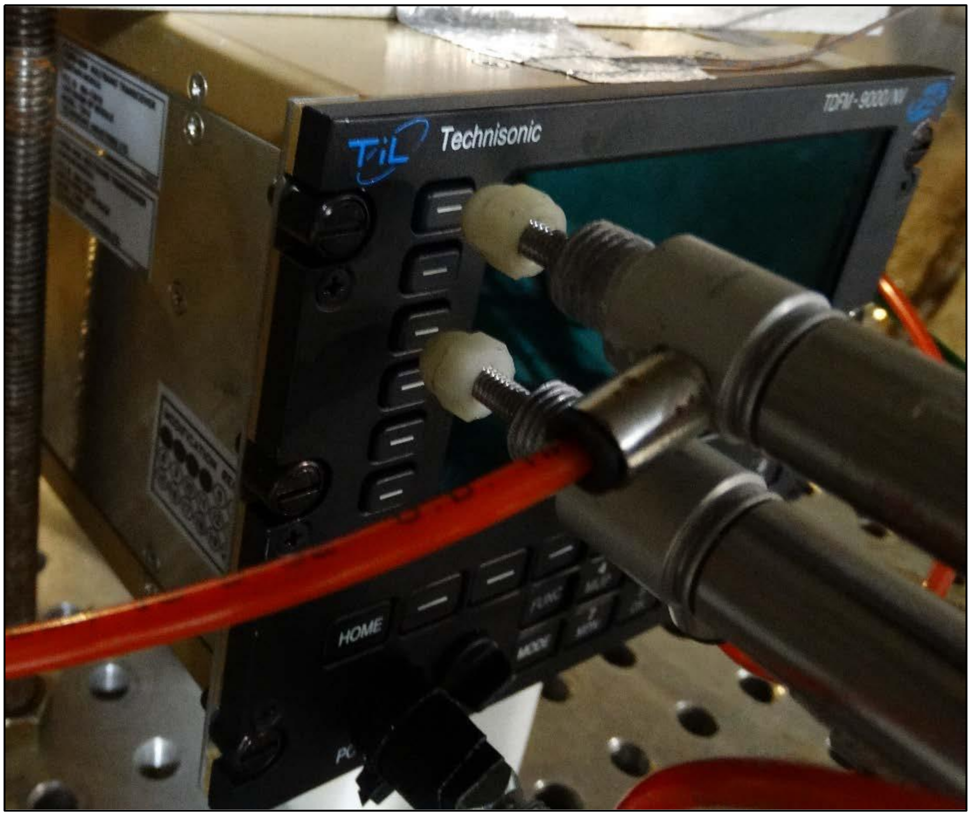


Figure 5. Actuators B and C Operating Separate Channel Selector Buttons.

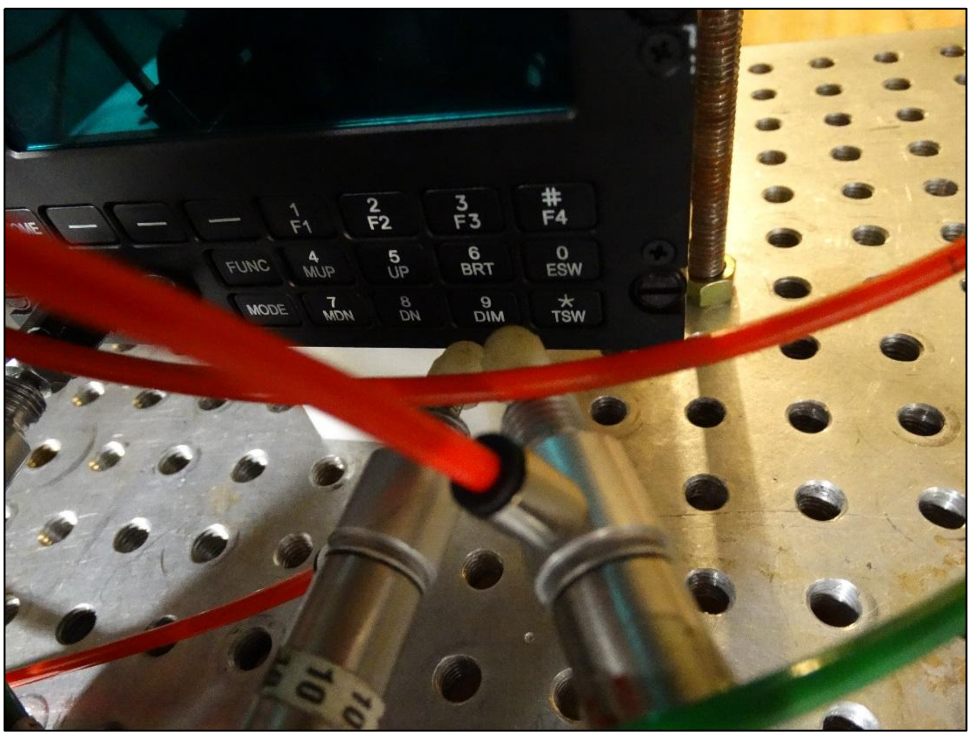


Figure 6. Actuators D and E Operating the Lighting Display Buttons.

The chamber was sealed, and the temperature was allowed to stabilize at ambient temperature prior to testing IAW the test plan. After the chamber was heated to 160°F (71°C), the FCP was then initiated at pre-determined altitudes (see Appendix B). With the test temperature sustained, n-hexane was introduced into the chamber at a simulated altitude of 26,600 ft and again at a simulated altitude of approximately 6,600 ft. The calculations used to derive the n-hexane volumes were computed per MIL-STD-810G and are presented in Appendix A.

The rate of change of simulated altitude (i.e., atmospheric-pressure equivalent) was maintained within specified parameters of approximately ≤ 300 ft/min. The test item was monitored throughout the test to ensure continued proper operation. The test regimen is summarized in Table 2.

Table 2. EA Testing Regimen at 160°F (71°C).

Item(s) Tested	**Part Number**	**Serial Number**
TDFM-9000 Radio	101263-2-90-A1DAGO	FTA10214
Altitude	**Description**	
26,530	Introduced 232.21 mL of n-hexane fuel to the chamber	
23,300	**Sample test complete**	
23,100	Begin FCP #1	
22,360	**FCP #1 complete**	
22,280	Begin FCP #2	
21,000	**FCP #2 complete**	
20,700	Begin FCP #3	
19,500	**FCP #3 complete**	
19,300	Begin FCP #4	
17,000	**FCP #4 complete**	
6,600	Added 273.13 mL of n-hexane fuel to the chamber	
3,300	**Sample test complete**	
3,200	Begin FCP #5	
2,700	**FCP #5 complete**	
2,670	Begin FCP #6	
2,270	**FCP #6 complete**	
2,000	Begin FCP #7	
1,600	**FCP #7 complete**	
1,570	Begin FCP #8	
1,000	**FCP #8 complete**	
0	**Sample test complete**	

2.1.3.2 Findings

A post-test visual inspection was conducted by personnel from the RTC Propulsion Test Division to note any anomalies or discrepancies, such as loose fasteners or connections, integrity of seals and sealants, or permanent distortion or deformation of material possibly affecting item functionality. No visual anomalies were noted.

The TDFM-9000 Radio was tested at various altitudes within a specified explosive atmosphere to determine whether operation of the test item would initiate ignition of that atmosphere. The test item, when so operated, did not ignite the explosive atmosphere.

Data recorded during testing was collected and is archived at the RTC Propulsion Test Division, and is available upon request. Data graphs for the test, showing the rate of altitude versus time, as well as temperature versus time, are provided in Appendix B.

2.1.4 Summary

The TDFM-9000 Radio was tested successfully, without igniting the fuel in the vacuum chamber. The RTC Propulsion Test Division satisfied the test purpose and objective of the EA testing of the TDFM-9000 Radio with no test or data anomalies.

APPENDIX A

SUPPLEMENTAL TEST PROCEDURE DOCUMENTATION

EXPLOSIVE ATMOSPHERE CALCULATIONS AND TEST TABLE.

N-hexane volumes were computed per MIL-STD-810G and using the following parameters:

Chamber Temperature = 160°F/71°C (344.26 Kelvin)
Specific Gravity of n-hexane = 0.655
Net Chamber Volume = 2,633.5 Liters

1. At a test altitude of 20,000 ft, chamber pressure is equal to 46,563.26 Pascals. Therefore, the volume of 95% n-hexane (mL) =

$$4.27x10^{-4}\left[\frac{2{,}633.5\ \mathit{Liters} * 46{,}563.26\ \mathit{Pascals}}{344.26\ \mathit{Kelvin} * 0.655}\right] = 232.21\ \text{mL}$$

2. At site level, chamber pressure is equal to 101,332.25 Pascals. Therefore, the volume of 95% n-hexane (mL) =

$$4.27x10^{-4}\left[\frac{2{,}633.5\ \mathit{Liters} * 101{,}332.248\ \mathit{Pascals}}{344.26\ \mathit{Kelvin} * 0.655}\right] = 505.34\ \text{mL}$$

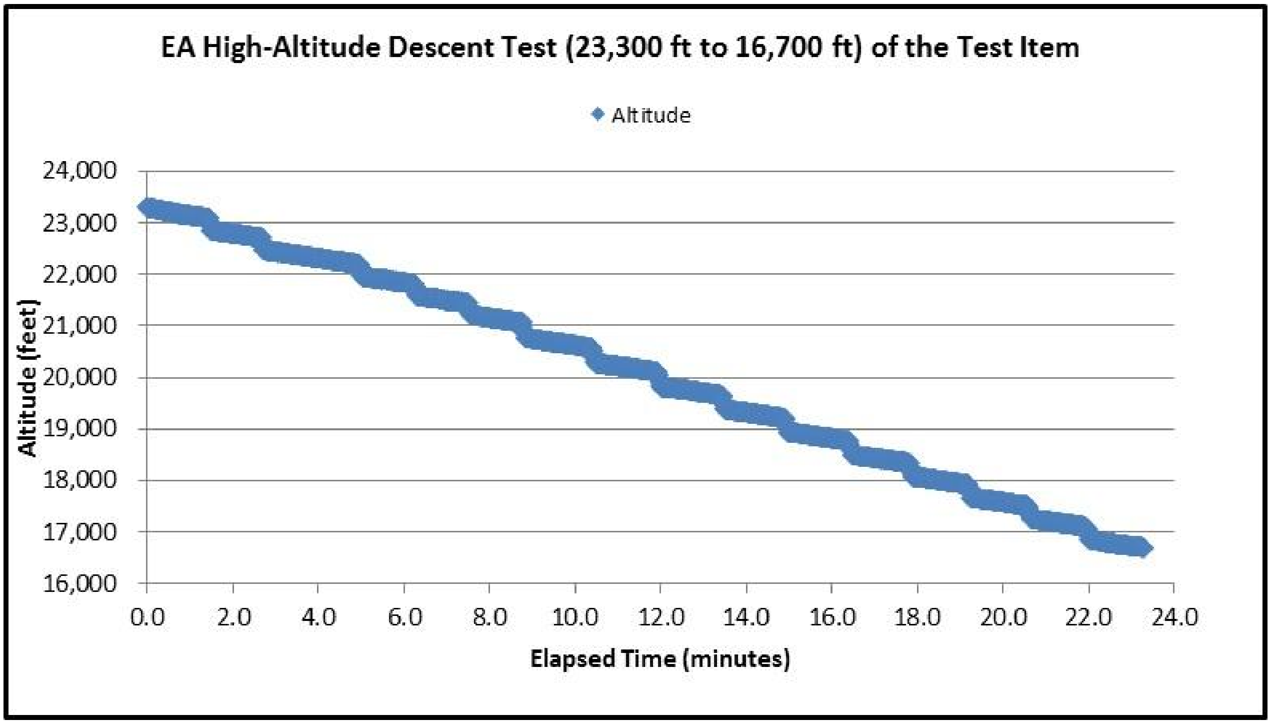
Since 505.34 mL of n-hexane is required at site level and 232.21 mL was already present, an additional 273.13 mL (505.34 mL – 232.21 mL) was introduced into the chamber at this altitude. These computations are based on an operating maximum test altitude of 20,000 ft and are summarized in Table A-1.

Table A-1. EA Test Matrix.

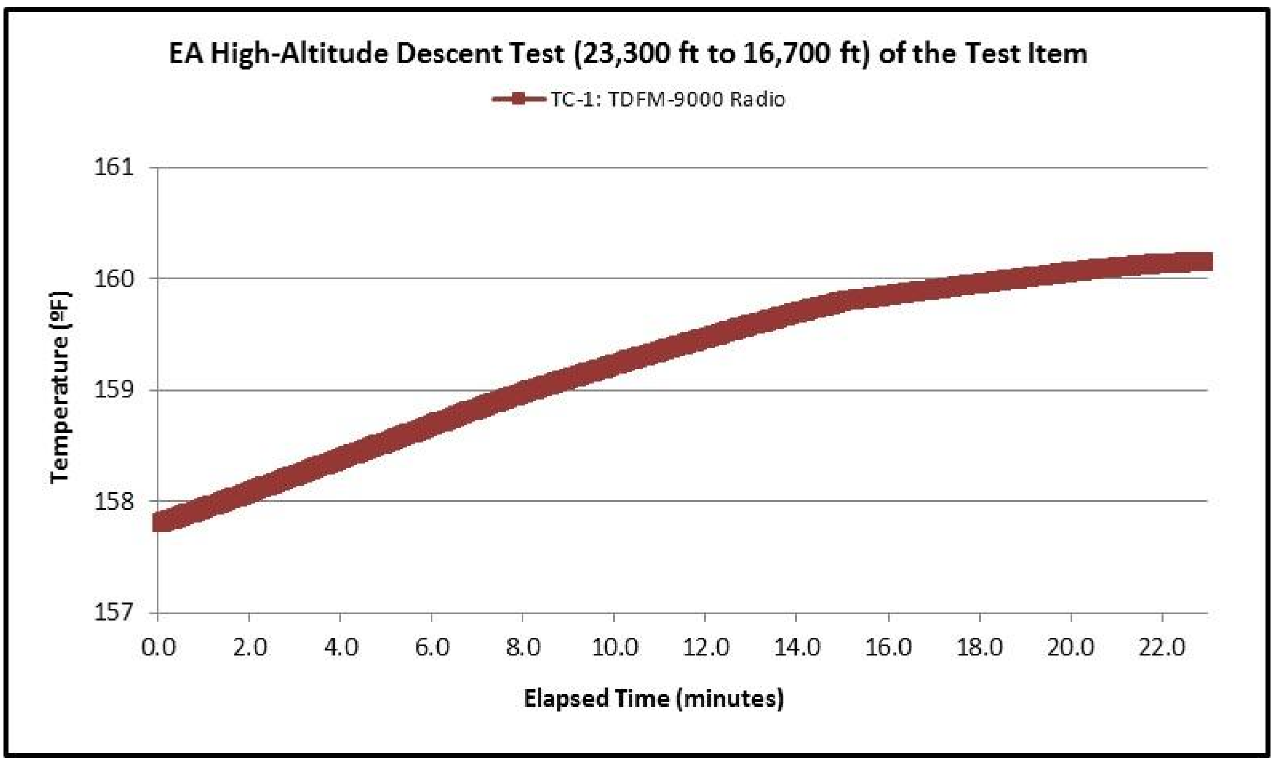
TEST ALTITUDE	CALCULATED ALTITUDE	CHAMBER PRESSURE (Pascal)	CHAMBER PRESSURE (PSIA)	FUEL (N-Hexane)	FUEL TO ADD (N-Hexane)
8,107.7 m 26,600 ft	8,108.0 m 26,601 ft	35,048.73	5.08	N/A	232.21 mL 7.85 oz
7,101.8 m 23,300 ft	7,102.1 m 23,301 ft	40,475.41	5.87	Test Atmosphere Start Recording	N/A
6,096.0 m 20,000 ft	6,096.3 m 20,001 ft	46,563.26	6.75	Test Altitude	N/A
5,090.2 m 16,700 ft	5,089.9 m 16,699 ft	53,372.23	7.74	Stop Recording Test Atmosphere	N/A
2,011.7 m 6,600 ft	2,011.4 m 6,599 ft	79,380.00	11.51	505.34 mL 17.09 oz	273.13 mL 9.24 oz
1,005.8 m 3,300 ft	1,006.1 m 3,301 ft	89,810.92	13.03	Test Atmosphere Start Recording	N/A
Site Level	Site Level	101,332.25	14.69	Test Altitude Stop Recording Test Atmosphere	N/A

APPENDIX B

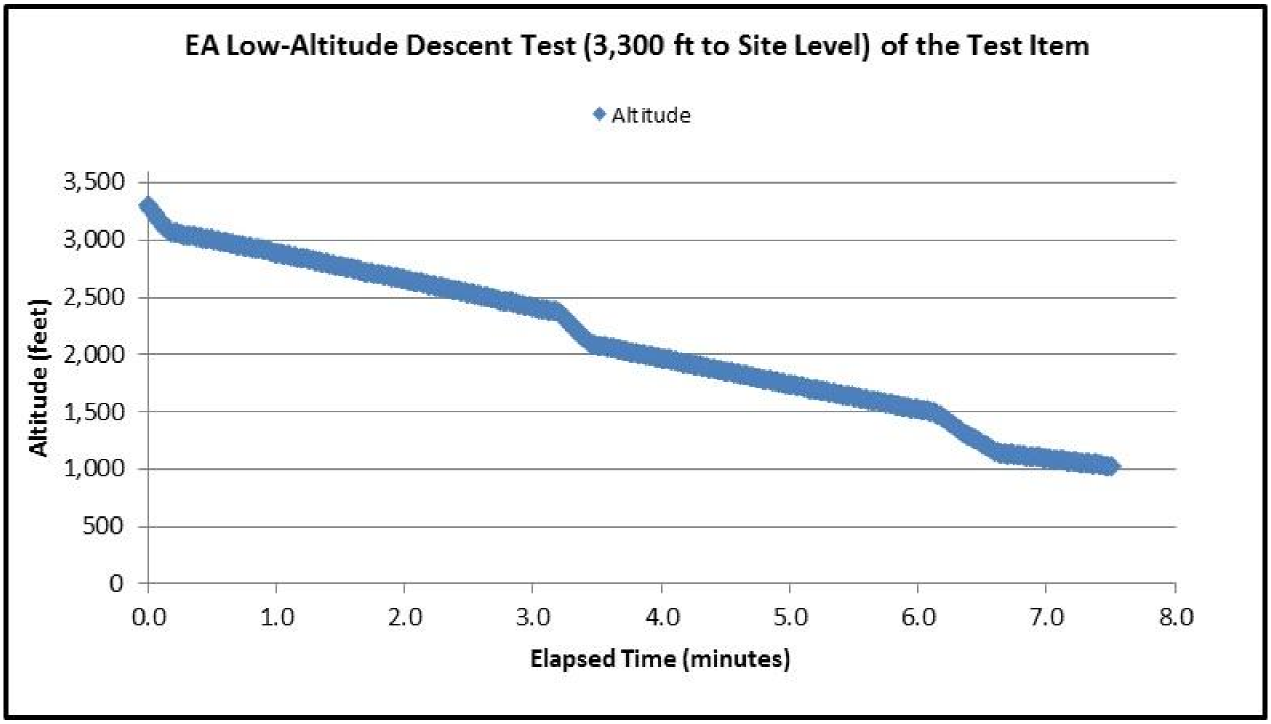
SUPPLEMENTAL TEST DATA



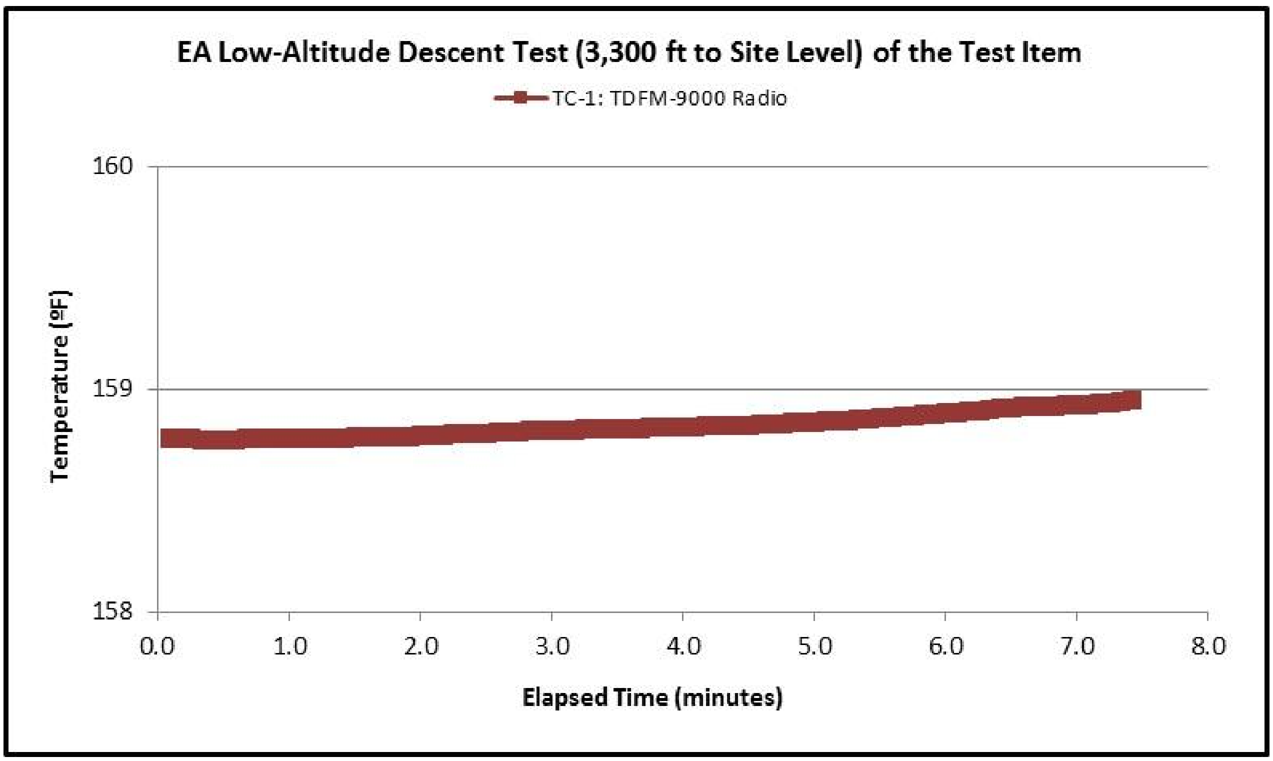
Graph B-1. Altitude versus Time for EA High-Altitude Descent Testing of the TDFM-9000 Radio.



Graph B-2. Temperature versus Time for EA High-Altitude Descent Testing of the TDFM-9000 Radio, TC-1.



Graph B-3. Altitude versus Time for EA Low-Altitude Descent Testing of the TDFM-9000 Radio.



Graph B-4. Temperature versus Time for EA Low-Altitude Descent Testing of the TDFM-9000 Radio, TC-1.

APPENDIX C

FUNCTIONAL CHECKOUT PROCEDURE LOG

TDFM9000 Functional Checkout Procedure (FCP) Data Sheet
Test Environment: Pre E/A test
Date/Time: 12/11/15 0922
Test Operator: K Cannon / J Johnson
Test Location: 4500

Unit Under Test (UUT) Inventory			
Item	**Manufacturer**	**Part Number**	**Serial Number**
TDFM9000	Techsonic	101263-2-90-A1DAGO	FTA~~10156~~ 10214

Functional Checkout Procedure (FCP)			
C.1.3 Visual Inspection	**Observe Condition**	**Pass**	**Fail**
Visual Inspection		JJ	
DC Power Supply Bar Code and Calibration Due Date	Date:		
C.1.5.2.1 TDFM9000 Radio	**Observe Condition**	**Pass**	**Fail**
B – Verify display functional		JJ	
C – Verify BRT and DIM button function		JJ	
D – Verify transmit/receiver function of VHF radio module		JJ	
E – Verify transmit/receiver function of UHF radio module		JJ	
F – Verify transmit/receiver function of 700/800MHz radio module		JJ	

TDFM9000 Monitoring Procedure (MP) Data Sheet
Test Environment: E/A Test
Date: 12/14/15
Test Operator: K Cannon J Johnson
Test Location: 8855

Unit Under Test (UUT) Inventory			
Item	**Manufacturer**	**Part Number**	**Serial Number**
TDFM9000	Techsonic	101263-2-90-A1DAGO	FTA~~10156~~ 10214

Monitoring Procedure (MP)				
C.1.6.0 Monitoring Procedure	**Time**	**Observe Condition**	**Pass**	**Fail**
B – Verify transmit/receiver function of VHF radio module	0947	23.1 K	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	0950	22.280 K	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	0955	20.700 K	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	1000	19.300 K	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	1022	3,200	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	1024	2,470	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	1025	2,000	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module	1027	1,570	[illegible]	
C – Verify transmit/receiver function of UHF radio module			[illegible]	
D – Verify transmit/receiver function of 700/800MHz radio module			[illegible]	
B – Verify transmit/receiver function of VHF radio module				
C – Verify transmit/receiver function of UHF radio module				
D – Verify transmit/receiver function of 700/800MHz radio module				

TDFM9000 Functional Checkout Procedure (FCP) Data Sheet
Test Environment: Post ETA
Date/Time: 12/14/15 1040
Test Operator: R. Elliott
Test Location: 4500

Unit Under Test (UUT) Inventory			
Item	**Manufacturer**	**Part Number**	**Serial Number**
TDFM9000	Techsonic	101263-2-90-A1DAGO	FTA1014

Functional Checkout Procedure (FCP)			
C.1.3 Visual Inspection	**Observe Condition**	**Pass**	**Fail**
Visual Inspection		RE	
DC Power Supply Bar Code and Calibration Due Date	Date:	RE	
C.1.5.2.1 TDFM9000 Radio	**Observe Condition**	**Pass**	**Fail**
B – Verify display functional		RE	
C – Verify BRT and DIM button function		RE	
D – Verify transmit/receiver function of VHF radio module		RE	
E – Verify transmit/receiver function of UHF radio module		RE	
F – Verify transmit/receiver function of 700/800MHz radio module		RE	

APPENDIX D

ABBREVIATIONS AND ACRONYMS

ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Description
AKO	Army Knowledge Online
AL	Alabama
AMRDEC	Aviation and Missile Research, Development and Engineering Center
ATEC	Army Test and Evaluation Command
Bldg.	Building
°C	(degrees) Celsius
CD	Compact Disc
CH	Cargo Helicopter
DoD	Department of Defense
EA	Explosive Atmosphere
°F	(degrees) Fahrenheit
FALCN	Flexible Aviation Laboratory Control Network
FCP	Functional Checkout Procedure
FM	Frequency Modulated
FOIA	Freedom of Information Act
ft	foot/feet
ft/min	foot or feet per minute
IAW	In Accordance With
m	Meter
MD	Maryland
MHz	MegaHertz
min	minute(s)
mL	Milliliter
N/A	Not Applicable or Not Available
NIPR	Non-Secure Internet Protocol Router
No.	Number
OPSEC	Operations Security
oz	ounce(s)
PM	Project Management
P/N	Part Number
POC	Point of Contact
PSIA	Pounds per Square Inch Absolute
RF	Radio Frequency
RTC	Redstone Test Center
SIPR	Secure Internet Protocol Router
SN	Serial Number
SOF	Safety of Flight
TC	Thermocouple
TIR	Test Incident Report
UHF	Ultra-High Frequency
U.S.	United States
VA	Virginia
VHF	Very High Frequency

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